GREEN CONSTRUCTION: EFFICIENT DESIGN FOR MILITARY FACILITIES

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SECURITY CLEARANCE

Upon initial award of the research grant from the Institute of Security Studies, Lieutenant Sheller notified his chain of command to include his Squadron and Group Commanders, the public affairs office, the intelligence officer, the civil engineering office, as well as the Wing Commander at the time The 144th Fighter Wing of the California Air National Guard does not have a full-time policy and review officer, therefore, this paper has not been cleared at the time of this printing. Lt Sheller will be providing a copy of this paper to the above aforementioned individuals/offices, but will not be soliciting further security clearances for the content within Any amendments will be forwarded to INSS, as needed, based on any apparent or perceived security violation(s) in the subject matter

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PREFACE

I was motivated to apply for this research grant to expand on my educational background in energy efficient applications with respect toward military construction.

Having just "moved-in" to a new military facility over the last year, I was impressed with most of the aspects of the construction process But more often, the construction quality and lack of attention to sustainable construction processes and management techniques disturbed me From the owner's perspective (the Government), one might blame the general contractor (g c) "He built the building, and now we have on-going problems with air conditioning, ventilation, and construction quality issues " Partial blame is due to the general contractor, however, I place a higher responsibility on the design process, the civil engineer, the plans and specifications, a lack of a construction team, and the overall deficiency in minimum energy efficiency standards

My desire is that this paper would provide a foundation for further discussion on the process of how the military design and construction community can provide adequate and efficient buildings I am optimistic that a more fundamental and straightforward energy policy could be adopted by the DoD and made available to those front-line commanders who want to become a catalysts toward a construction process that produce an excellent structure that saves energy and provides people with an excellent work environment

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ABSTRACT

The Department of Defense (DoD), in its military design and construction procedures, is struggling with how to adjust to quality and budgetary constraints, while providing its workforce, the men and women who guard this nation, with office, housing, and maintenance buildings that comply with energy efficient standards

The paradigms of environmental design, sustainable design, or green construction within the building professions of architecture, engineering, and construction provides for extremely broad applications toward practical use. The definitions and their approaches toward the final structure produce fragmented policies on the best approach toward producing a practical energy efficient building – which, in reality, needs to be the end goal

The objective of this study is to provide a foundation for further investigation and research in green construction and sustainable design applications for military facilities There exist many volumes of government documents, case studies, executive orders, and military policies related to green construction practices, however, their exists no standard policy that front-line commanders can focus on to provide quality, energy efficient buildings for their people

The results of this study arrange a contemporary foundation in the broad energy policies that exist, but expands in current governmental policies and procedures to illustrate the possibility of adoption of a standard model that could be employed by the DoD Commanders A practical energy model that will provide individuals in the

construction profession a set model that is employable at the front-line command level as well as allowing flexibility in further application toward higher or more efficient buildings

INTRODUCTION

Initial Goals of the Research

This research project initially was to focus on USAF policies and procedures toward integrating green construction techniques into military facilities based on Executive Order # 13123 – Greening the Government through Leadership in Environmental Management. Upon further consultation, the research was expanded to include the sister services and how they accomplish the broader aspects of green construction processes. This unique cross flow research project provided a distinct challenge in data acquisition for such a preliminary paper. Therefore, the intention of this paper is to provide an introductory précis in the aspects of green construction: efficient design for military facilities. This research paper will present five goals that are based on extensive background research of sustainable policies as well as interviews with military and government officials that directly affect the outcome of the green construction process.

The first of five goals are based on assumptions of the current military construction community. This community, much like its civilian profession counterpart, holds the designer; architect or engineer, at a higher level of professionalism than the general technician trades of the contractor, builder or construction manager. This rank structure proliferates throughout the building community and actually segregates the building team that generally wants to provide the owner with a quality, energy efficient structure.

Project or contract delivery systems of the twenty-first century vary from the standard design-bid-build formats of the past.[1] Today, utilization of design-build and construction management delivery systems is increasing and owner satisfaction, building efficiency, and quality control generally parallel the non-standard system. One must note, however, that the design-bid-build process relies heavily on the architect or engineer to provide quality plans and specifications – specifications that either are "standard" in nature, or challenge the builder to become a team member who produces an energy efficient structure.

The second goal undertaken in this research is to provide a précis of the current national and military energy policies, efficient building materials and energy codes that exist. This is no small task. With the light speed technology changes that are taking place daily within the energy community, this paper admittedly indicates a small number of the total possibilities that might be available in building a military facility. The second goal, however, is necessary in providing a foundation for further study within the application of green construction. This research paper focuses, by its characteristic, in providing a summary view on practical applications of energy codes and policies. A building that is merely "energy efficient" is just and honorable within the aspects of our finite energy resources and escalating costs. A building that is beyond a simplistic definition of "energy efficient," is more than achievable, but not necessary practical in all cases.

The third goal of this paper is to facilitate discussion on the discord between the Department of Defense (DoD) branches and their individualistic approaches toward military construction and green practices. What aspects should the US Air Force, US Navy, or US Army be discussing when it comes to producing a standard model that might

be followed by all of the services during initial design and construction. One might point to the basic fundamental aspect of the difference in mission and application of the services. This researcher, however, indicates that a basic building: office, maintenance, or housing; must still include standard components that are adaptable to energy efficient applications. One main and identifiable component is the heating, ventilating, and air conditioning (HVAC) system. Regardless of the branches mission or location of the base, post or facility in the world, an HVAC system with set energy efficient components can provide for a starting point in the process of providing an overall energy efficient building.

The fourth goal is to provide a summary in case study applications of basic components in green construction. Utilizing a small number of past and current case study projects, the research provides a link to what may be possible to achieve. In addition, a case study of a current project is component analyzed to indicate if the specifications could have been modified to indicate green construction principles.

The fifth and final goal of the research was to provide a typical energy efficient model that might be adaptable to the DoD. Facility commanders have a tremendous amount of authority on how a structure is built and what components are included within the particular structure. This is not to suggest that commanders are micro-managing the building process – nothing further from the truth. Most commanders allow their base professionals to accomplish their job without interruption. However, a simple and introductory checklist or question sheet that a commander could rely upon is the goal here. Not to further inundate the commander and his or her base or regional design professionals with another policy, instruction, or regulation that must be followed.

Organization of the Paper

The paper is organized into five main sections that provide background and viewpoints into the complexity of green construction principles.

The first section contains background on the paradigms of environmental design, green construction, and sustainable design. Unique in their individual process, this research paper intends to find a commonality between the aspects of an energy efficient building and the relationships of the above mentioned disciplines.

The second section will review the current status of national energy policy and applicable codes that currently exist What policies, codes and processes that are applicable or might be available to the military construction community when panning for a new or remodeled facility.

The third of the five sections is an introduction to the current military design and energy guidelines. Admittedly, these guidelines are not always followed or reviewed prior to the initial planning or beginning of a building. However, they are integral to the overall research in their complexity and adaptation to the military-construction (milcon) process.

The forth section is an inauguration of several green construction case studies. These studies focus on major aspects of the green construction process to provide a background into what the design process might be focusing on when beginning the initial planning of a building.

The fifth and final section of the paper is an attempt to provide an introductory standard that might provide for further research in this area. After conducting a number

of interviews, my research determined that there must be a hands-on approach to energy efficient design – no matter what the overall disciple is referred to. The approach should have basic fundamental characteristics and not be so overwhelmingly complicated that the production value might overshadow the structure.

Green Construction and Sustainable Design Background

"Business and other human endeavors are bound by invisible fabrics of interrelated actions, which often take years to fully play out their effects on each other Since we are part of that lacework ourselves, it's doubly hard to see the whole pattern of change Instead, we tend to focus on snapshots of isolated parts of the system, and wonder why our deepest problems never seem to get solved " [2]

The disciplines of the construction profession are often easy to define. In simplistic terms, architecture is the act of design and refinement, engineering is the act of structural design and placement, and construction is the act of building. One has difficulty, however, with clear definitions of the sub-disciplines within the construction profession that are related to the environment and intertwine with energy efficiency.

By definition, sustain, as a root of sustainability is *to endure.*[3] A structure, by the end achievement of construction, is by all human nature, supposed to endure. To endure rain, snow, sun, effects of the occupants, and as a habitable space for years to come. But that being noted, buildings often don't accomplish this somewhat simplistic task. Not all buildings are energy efficient. The DoD is the largest single user of energy in the United States.[4] It spends more than two billion annually on electricity.[5] A mere two percent reduction in energy costs based on more efficient facilities and/or alternative energy production equates to a massive forty-million dollar savings. In most instances, that is more than a base, post or facilities entire operating budget. Furthermore, not all buildings endure to stay habitable. Too often, commercial buildings are experiencing "sick building

syndrome" (SBS). This term is used to describe a pattern of heath complaints related to poor indoor air quality (IAQ).[6] By contrast, the Environmental Protection Agency (EPA) has also deemed the term "building related illness" (BRI).[7] BRI is used when there can be specific diagnosable symptoms can be traced or directly attributed to airborne building contaminants.[8]

It is necessary to stray away from mere habitability or not fully compliant to simplistic energy efficient standards. Constriction profession sub-disciplines facilitate a further understanding of the building process that relates to the environment while practicing energy efficiency. What follows is a listing of definitions that provide a foundation as to what green building is all about.

Sustainability is responsible stewardship of our natural, human and financial resources through a practical and balanced approach. Sustainability requires changes to the facility delivery process to ensure the best fit of the built environment to the natural and cultural environment.[9]

Environmental Design is defined as design that deals with man's forethought's, concepts, and ideas about the betterment of situations regarding him and everything that surrounds him.[10] This lofty task is plagued by the many influences of architecture, engineering, construction, and the environment a whole.

Sustainable Development refers to structures and designs that cause no overall net environmental burden or deficit Beginning with the earliest stages of project planning, sustainable development considers a building's total economic and environmental impact and performance. From raw material extraction and product manufacture to product

transportation, building design and construction, operations and maintenance, and finally, building reuse or disposal.[11]

Sustainable Building is essentially the use of design and construction methods and materials that are resource efficient and will not compromise the health of the environment or the associated heath and well being of the buildings occupants, builders, the general public, or future generations.[12]

Sustainable Design means using the most energy efficient and environmentally sustainable products, optimizing architectural design to incorporate local natural conditions, such as day lighting, and passive/active solar and solar thermal applications, and providing for indoor workplace environmental quality.[13]

Green Construction is a complex definition relating to the "green" environmental practices that produce energy efficiency and integrating all phases of the construction process. Green construction is, therefore, providing for environmental energy efficiency though planning and design and incorporating these aspects into the entire construction process.

The above definition background into the disciplines and paradigms that exist within the environmental and energy efficient sub-disciplines of the construction profession provides one clear characteristic of their use - regardless of the overall approach, integration and the relationships of the building systems is the cornerstone. Much like the theories and practices of biology, one system utilizes another system to survive and sustain itself. Therefore, an architect, engineer, or builder can not perform alone in a vacuum nor is he or she expected to perform without the guidance, communication, and professionalism of each other. The cornerstone of integration is

further built upon by the development of the buildings interior and exterior systems. One system can provide for a give-and-take of another system and still accomplish its goal of becoming an energy efficient and environmental aware building. Furthermore, it's this holistic approach to planning, environmental management, and integrated design concepts[14] that provides the key to green construction: efficient design for military facilities.

Energy Codes and Policies

> *The Department of Defense must improve its environmental performance by actively implementing policies that embrace pollution prevention in all phases of the acquisition process, the procurement of goods and services, and life-cycle management of our installations.* [15]

In the subsequent section of this paper, national and international energy codes, executive orders, energy programs that facilitate sustainability, and a list of military energy policies and programs will be inventoried. These listings should expand on the complexity of providing a standard policy in providing sustainable design in military facility construction

A major focus of this research paper is to establish a comprehensive listing of what currently exists in environmental and energy efficient codes, executive orders, and polices. To help the branches of the DoD, this paper will summarize the major civilian energy codes, those executive orders that apply to energy policies and directly affect the military construction community, and finally governmental energy policies that currently exist and are applicable to any DoD construction project In addition to these codes and policies, one must remember that an additional motivation toward the success of any

applicable code or policy is that it must be useable at the most basic level. It can not create volumes of additional bureaucratic regulation or inadvertently add extreme costs to the project by the necessity of compliance.

American Society of Heating, Refrigeration, and Air Conditioning Engineers - ASHRAE Standard 90.1. This standard was the first national consensus on commercial building energy efficiency. Utilization of thermal mass and United States climate zones allows this basic standard to go virtually unchanged for over a decade. Since its creation in 1989, this single standard has been adopted or incorporated within the BOCA National Building Code, the SBCCI Standard Building Code and other International energy codes.[16]

International Model Energy Code (formally CABO – Council of American Building Officials). This code has adapted over the years to evolve from the CABO Model Energy Code (MEC) to the International Energy Conservation Code. The MEC and its prior editions is a model energy code containing requirements for both residential and commercial construction.[17] The MEC is a downloadable energy code that can be utilized throughout the building communities.

Building Research Establishment Environmental Assessment Method – BREEAM. This program was developed in England and utilizes a self-assessment tool as part of its overall green building program.[18]

Building Environmental Performance Assessment Criteria – BEPAC. This Canadian program evaluates environmental performances for commercial buildings.[19]

International Organization for Standardization - ISO 14000. This criteria sets a series of environmental standards and guideline documents in the area of environmental management systems.[20]

Building for Environmental and Economic Sustainability – BEES. This program, developed by the EPA, is aimed at designers, builders, and product manufactures to provide actual environmental and economic performance data for an extensive listing of building products.[21]

Leadership in Energy and Environmental Design – LEED. The LEED Green Building Rating System is a priority program of the US Green Building Council. This program evaluates environmental performance from a whole-building perspective over a buildings life cycle, providing for a definitive standard for what constitutes a green building. (note) The LEED Program is also available through a download purchase; however, there are additional certification requirements to be endorsed by LEED.[22]

In addition to the above summary of available energy performance standards and programs, each CONUS base, post or facility may be able to take advantage of the utilization of individual state energy programs. For example, in the state of California, each base, post or facility would be able to employ the aspects of the California Energy Code - Title 24. In most cases, this one state code may produce a more energy efficient building than that of compliance with a national energy code.

United States Energy Policy Act of 1992 – EPACT. This comprehensive energy act covers many areas including energy efficiency.[2.]

Code of Federal Regulation – 40 CFR 247. This Comprehensive Procurement Guideline identifies thirty-six items that are, or can be, manufactured using recycled or recovered materials.[24]

Code of Federal Regulation – 10 CFR 435. This Energy Conservation Voluntary Performance Standards for New Buildings – Mandatory for Federal Buildings The code contains minimum requirements for building energy management systems.[25]

Code of Federal Regulation – 10 CFR 436. This code establishes procedures for determining the life cycle cost effectiveness of energy conservation measures of existing Federal buildings.[26]

Executive Order – EO 12843. Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances. Requires Federal agencies to maximize the use of safe alternatives to ozone-depleting substances.[27]

Executive Order – EO 12844. Federal Use of Alternative Fueled Vehicles. Requires the Federal Government to adopt aggressive plans to acquire alternative fueled vehicles.[28]

Executive Order – 12845. Requiring Agencies to Purchase Energy-Efficient Computer Equipment.[29]

Executive Order – EO 12873. Federal Acquisition, Recycling and Waste Prevention. This EO mandates that federal agencies incorporate waste prevention and recycling into daily operations.[30]

Executive Order – EO 12902. Energy Efficiency and Water Conservation at Federal Facilities. Requires facilities to be designed or constructed in a manner, which minimizes the life cycle cost of the facility.[31]

Executive Order – EO 13101. Greening the Government through Waste Prevention, Recycling, and Federal Acquisition [32]

Executive Order – EO 13134. Developing Biobased Products.[33]

Executive Order 13123. Greening the Government through Leadership in Environmental Management. This order signifies that the Federal Government can lead the Nation in energy efficient building design, construction, and operation. EO 13123, released on 22 April 2000, is essentially the pinnacle of governmental policy in relationship toward green construction practices. This research paper sets its foundation on the several policies and codes, however, none as important as this one EO. Environmental management considerations are a fundamental and integral component of Federal Government policies, operations, planning, and management [34]

Federal Energy Management Program – FEMP. This program, as part of the Department of Energy (DOE) helps federal agencies reduce their costs, increase energy efficiency, use renewable energy, and conserve water.[35]

Sustainable Building Technical Manual – Green Building Design, Construction, and Operations. This extensive manual is produced by Public Technology Incorporated, the US Green Building Council, and sponsored by the US Department of Energy and the US Environmental Protection Agency. The goal of this manual is to provide clear, easily applied guidelines and useful practices that can be readily introduced into new construction, renovation, and building operations.[36]

Green Seal. This independent, nonprofit organization is dedicated to protecting the environment by promoting the manufacture and sale of environmentally responsible consumer products. It sets environmental standards and awards a "Green Seal of

Approval" to products that cause less harm to the environment than other similar products.[37]

Energy Efficiency and Renewable Energy Network – EREN. This US Department of Energy Program is responsible for the Million Solar Roofs Initiative.[38]

Center of Excellence for Sustainable Development. A project of the US Department of Energy that provides communities with information and strategies on producing sustainable development cities, neighborhoods and regions.[39]

Energy Star Program. This program is operated jointly by the U.S Department of Energy and the U.S. Environmental Protection Agency. This program provides minimum energy efficiency Government standards for manufactures to meet in order to manufacture their appliances with the energy star label.[40] For example, an Energy Star rated compact fluorescent light bulb that replaces a standard incandescent bulb will save a minimum of twenty-five dollars in energy costs over the life of the bulb. Multiply that one-bulb savings by hundreds of thousand of DoD light bulbs and you start to achieve a working knowledge of what basic energy efficiency will be able to accomplish. In addition to product manufacture requirements, the Energy Star Program also provides guidelines for building to become Energy Star compliant.[41]

Current Military Design and Energy Guidelines

Expanding on the above summary of codes, orders, and programs is the following outline for regulations and policies relating to the DoD energy guidelines and individual branch summaries of policy and instructions that relate to green construction practices or sustainability in construction.

DoD Directive 4170.10 – Energy Conservation. Updates DoD policy, assigns responsibilities, and prescribes procedures for DoD energy Management.[42]

Defense Energy Support Center – DESC. Agency that will assist DoD facilities in establishing Energy Saving Performance Contracts. These contracts utilize savings from energy efficiency actions to finance the ESPC program.[43]

Sustainable Installations Rating Tool – SIRT. The U.S. Army Engineer Research and Development Center developed this DoD prototype. The overall approach is based on a point rating value for facility development as well as operations and maintenance, including mission application.[44]

Sustainable Project Rating Tool – SPRT. Using the SIRT prototype, the SPRT was developed to provide the DoD with a standard tool for sustainable design projects.[45]

Air Force Instruction 32-1023 – Design and Construction Standards and Execution of Facility Construction Projects. This AFI provides general design criteria and standards; procedures for developing engineering technical letters and technical data publications; guidance on selecting architect-engineering firms and information on design and construction management.[46]

United States Air Force Environmentally Responsible Facilities Guide. This guide provides comprehensive applications toward sustainable facilities design and contract development. (Basis of the guide links to AFI 32-7062 - Comprehensive Planning)[47]

USAF Center for Environmental Excellence – Brooks AFB, Texas. Currently working on a draft policy for incorporating sustainability concepts in planning, design, construction, operation and disposal of facilities and infrastructure projects [48]

US Army Corps of Engineers – Construction Engineering Research Laboratory – CERL. Provides information on material research and sustainable design process and developed the Sustainable Project Rating Tool – SPRT.[49]

Army Environmental Policy Institute – AEPI. Provide policy support and recommendations on many environmental issues facing the US Army.[50]

Naval Facilities – NAVFAC Planning and Design Policy Statement 98-01. Design of Sustainable Facilities and Infrastructure. This policy statement requires NAVFAC to incorporate sustainability principles and concepts in the design of all facilities and infrastructure projects to the fullest extent possible.[51]

Naval Facilities – NAVFAC Planning and Design Policy Statement 98-02. Criteria Supporting the Design of Sustainable Facilities and Infrastructure. This forward thinking policy requires NAVFAC to adopt and utilize industry-recognized standards, codes, and criteria and other guidance in support of sustainable design whenever possible in lieu of establishing Navy-unique documentation.[52]

Naval Facilities – NAVFAC Planning and Design Policy Statement 98-03. Further requires NAVFAC to select architects and engineers (A-Es) for design and related professional services on the basis of their knowledge and demonstrated experience in applying sustainability concepts and principles to facilities and infrastructure problems through and integrated design approach.[53]

Tri-Service Working Group – Unified Design Guidance. Evaluated design criteria documents for the services and found that forty-three percent of the Services design criteria are unified. This Working Group focused on common specifications, design tools, and databases, not necessarily sustainable design practices.[54]

The proceeding pages illustrate the complexity of the sustainable design paradigm. These codes and policies are, by themselves, to complex for front-line commanders and staff. Best practices are demonstrated in simplistic uses like the USAF Environmentally Responsible Facilities Guide and the NAVFAC Planning and Design Policy Statement 98-02.

Case Study Applications

Utilizing past and current case studies, this section devotes a part of this paper to a small number of case studies This allows for an introductory education of what has worked from the standpoint of green construction applications in federal and military facilities. In addition, this section points out some discrepancies in a building that is currently under construction and would have benefited from green construction applications and a standard model toward accomplishing energy efficient design.

Solar Photovoltaic Projects:

Grasmere Range, Mountain Home AFB, Idaho This project provides solar power to electric equipment that was previously powered by diesel engines located on a range approximately forty miles from the nearest utility grid.[55]

Range 500, Twenty-nine Palms Marine Base, California. This solar and diesel hybrid project provides supplemental power for tank targets.[56]

Fort Carson, U.S. Army, Colorado. Solar powered installation of different water pumping stations that replaced aging windmills.[57]

China Lake Naval Weapons Center, California. Multiple solar power and diesel hybrid applications on remote systems throughout the range.[58]

Wind Farm Projects:

Ascension Island wind farm. Wind farm supplements the diesel power plant that supplies energy for the entire island. Roughly, the installed turbines save three-hundred thousand gallons of diesel fuel annually.[59]

San Clemente Island, California. Installation of a wind farm to supplement the diesel power plant at the Naval Air Facility. Wind generated from this facility reduces the need for thousands of gallons of diesel fuel annually.[60]

Geothermal Projects:

By far the most noted geothermal project is the Naval Air Weapons Station (NAWS), China Lake, California. This facility has been in operation since prior to 1986 and has been producing energy not only for the base facility but also for the surrounding community. During 1995, direct energy reduction at the NAWS equated to $2.8 million dollars – a 27% reduction in electrical energy costs.[61]

Electrical Retrofit:

Randolph AFB, San Antonio, Texas. Utilizing an Energy Savings Performance Contract (ESPC) to form a partnership with a manufacture, the energy manager financed approximately $1.8 million dollars for the cost of new T8 fluorescent lamps and new equipment. The USAF expects to save over $500,000 dollars a year in energy costs through this project.[62]

Native Landscape Design and Management (Xeriscape):

Davis-Monthan AFB, New Mexico. Utilizing Xeriscape planting and native landscape applications, trees shaded the Palo Verde housing complex. This directly reduced energy costs as well as and reducing storm water runoff and improved air quality. Annual savings were in excess of $50,000 and storm water runoff was reduced by 32% annually.[63]

United States Postal Service, Lake Havasu City, Arizona. Utilizing a landscaping partnership, the retrofit of the 1970 irrigation system that was dependent on underground water. The redesign utilized Xeriscape principles to shade the building reducing energy costs as well as using native drought resistant plants, shrubs, and trees to reduce the water demand and run-off.[64]

Energy Code Adaptation:

Fort Irwin, U.S. Army, Ft. Irwin California. The energy manager utilized the simplicity of the California Energy Code compliance data for building on-base housing facilities.[65]

Current Military Facility under Construction:

The next portion of this research paper is an on-going case study that is currently under construction. It is necessary to provide current applications and studies utilizing the aspects of green construction principles to provide a

comprehensive view of changes that need to be set into the construction process. This case study obtains information from the specifications and plans of the Composite Support Facility / Civil Engineering Readiness Facility – 144th Fighter Wing, Fresno California Air National Guard. This new "Wing" building will ultimately house the commander and Wing staff as well as a new dining facility and a separate structure accommodating C.E Prime BEEF Storage. This structure is currently in the intial stages of construction and the time-line for any improvements in the construction process is excellent. Any deficiencies that are noted below are strictly from the specifications and adaptable data from green construction codes and policies.[66] According to the plans and specifications, there are numerous applications that could have been adapted toward green construction principles.

i. Indoor Air Quality – Volatile Organic Compounds (VOC). VOC's are the noted by the EPA as being the main focus on the symptoms that cause poor IAQ and contribute to SBS. (note) The EPA and Green Seal indicate that the product specific environmental requirements for interior coatings should have a VOC concentration of no more than 150 for non-flat and 50 for flat. Specifications indicate that the manufactures and product descriptions chosen for this building have between 170 and 380 VOC's for interior and 250 for exterior coatings. Green Seal also indicates that non-VOC paints are available throughout the market. When referenced to the four product descriptions in the specifications, each of the paint and coating manufactures have a low-VOC product available – although it was not specified by the architect
ii. HVAC Systems. IAQ is key with ventilation systems. Fan systems don't indicate ASHRAE revised ventilation standards to provide up to 60 cfm/person depending on activities required in some spaces. Listed system manufacture efficiencies don't indicate specific applications toward energy life cycle cost analysis.
iii. Building Interior Systems should indicate low-VOC for floor finishes, countertops, and interior plywood applications

iv. Site applications in design indicate a south facing structure. Good use of passive solar design No use of neither alternative energy applications nor the use of Xeriscape principles in landscape design and applications.
v. Construction process and team members should focus on construction debris and recycling / reuse applications as applicable.

Utilizing the NASA generated SPECSINTACT and the standard Construction Specification Institute (CSI) building specifications, the use of green construction practices are available and need to become a standard part of any construction specification process. Admittedly, the above case study was placed at a disadvantage. By focusing on specific parts of the structure and not the whole building system. This researcher is not a part of the construction team, and therefore, is not attending meetings where hopefully these issues may be addressed. However, this case study illustrated a persistent problem in military construction – the members of the construction profession who generate the plans and specifications are placing base, post or facility commanders at a disadvantage in future energy savings. There should be a simple DoD publication and or checklist for a front-line base commander and his or her staff that will provide them with questions to pose at initial planning stages of the construction process.

Green Construction: Efficient Design for Military Facilities

This section is the culmination of my research though extensive interviews and policy and code review of practical applications in sustainable design. A re-examination of the definition of green construction is as follows; *Green construction provides for environmental energy efficiency though planning and design and incorporating these aspects into the entire construction process* This simplistic definition incorporates all of

the preceding data into a functional relationship of the building process. The end result of the extensive "milcon" process is a structure of some kind. Whether the buildings use depends on the individual mission of the separate branches of the DoD, or it's a rather simplistic remodel of a retail shopping center that will be used for recruiting services, its fundamental purpose is a building that must follow the construction process to be completed and habitable.

The "milcon" process could arguably develop into another research paper. Fundamentally, it must begin at the base, post or facility level with a need. The need of a building or structure to provide habitable space for its occupants. Once a need is established, the funding and design process differs throughout each of the services. Whether a service utilizes a regional design center to produce the plans and specifications, or allows for more local control over the initial phases of design differs greatly based on the location and service mission. Regardless of the process, however, an intertwined listing of construction professionals must be created. Architects, engineers, and constructors are intrinsically tied to a specific military facility project In addition, the base, post, or facility commander can generate interest and pressure to seek out new avenues of materials selection and architectural design systems, provided that he or she is educated in what questions to ask. The fundamental standard approach toward green construction: efficient design for military facilities bases its foundation on the commander's decision to be involved with any construction on his or her base, post or facility. Removing the micro-management of the construction process, but allowing DoD Commander's to formulate a basic understanding that they are going to require some type

of energy efficient design as well as produce aspects of sustainability within the construction process.

Standard Approach toward Green Construction: Efficient Design for Military Facilities

The following section exemplifies the main focus of this paper. A simplistic approach by which energy efficiency and green construction principles can be achieved by base or facility commanders. This section introduces ten tenants that can be set into a checklist for base commanders to pose questions to the civil engineering community and help force a green construction or sustainable project.

Expanding on the fundamentals of front-line DoD commanders having some type of checklist to initiate end answers in the initial design construction process, while providing experts within the construction professions applicable room for further energy compliance with any number of methods; this research focuses on ten tenets toward green construction and efficient design for military facilities. These ten tenants are further subdivided into four sections: pre-design, construction team selection, design and specification, construction, and post occupancy.

Pre-Design

Most often, all new construction on bases, posts, or facilities, is fixed in location. There may be a master site plan that places the approximate location of a building at the intersection of road X and Z, for example. Site selection, an overall important part of sustainability, is removed from the standard model. In addition, commanders must allow for fluctuation in the Pre-Design section. Most often, "milcon" spending is either rushed

because of budgetary constraints or surpluses, or slowed to a snails pace because of the same budgetary constraints or changes in mission priorities However, a planning approach toward the pre-design section can alleviate most of the last minute scuttle when "milcon" money becomes available for a specific project

i. Establishing goals and a mission statement for utilizing sustainability and green construction processes for the building. This intrinsic foundation toward what type of a building the commander wants to see must be an integral part of the Request for Proposals (RFP) or the Statement of Work (SOW) or during the "charette," a collaborative, cross-disciplinary work session.[67]

ii. The commander should be aware of the types and aspects of a standard model for determining energy efficiency that will be utilized. This model can be criteria set forth through the State that the base, post or facility is located in, a commercial model, or a standard government compliance model for federal facilities. Regardless of the choice, the end result must be an energy efficient building. Other applications are the possibility and availability of Energy Performance Contract (EPC) initiatives.

iii. Establish simplistic goals and statements for indoor air quality (IAQ). Set occupant health and well-being statements, waste reduction percentages, and pollution and prevention (P2) statements. These statements can be utilized in the materials specifications and post occupancy section of the checklist.

Construction Team Selection

It is extremely important to move beyond the typical architect-engineer (A-E) selection process. This does not imply that the only way to accomplish green construction principles is to move toward the design-build project delivery system. Where the team is essentially one firm is assigned responsibility (note) for the design and construction of the entire building while focusing on all aspects of the construction process. Green construction principles can be achieved regardless of the project delivery system. It is important, however, that if utilizing the standard design-bid-build contract, the "lowest bidder" must be elevated to the "lowest qualified bidder" with respect toward prior work in sustainable or green construction projects. Furthermore, the plans and specifications must be explicit in the manner by which sustainable and green construction materials and process are achieved.

iv. Initiate an architect-engineer-constructor-construction manager (A-E-C-CM) selection criterion that focuses on the construction profession team. Evaluate all aspects of the team with respect to prior experience in green construction projects.

Design and Specifications

One of the more important aspects of the plans and specifications is that they actually contain green construction materials and sustainability aspects with respect toward energy efficiency. No matter what the goals and mission are, if the ingredients are not compatible with green construction practices, then there is no way that the end result will be an efficient building.

v. Select energy efficient construction materials that will be utilized in the building construction process. In addition, provide for system component efficiencies that indicate minimum and maximum available for construction. This process is similar to energy ratings on appliances where a chart indicates the minimum and maximum efficiencies and the efficiency rating of the chosen appliance for budgetary comparison purposes. Utilize standard dimensions for the building to minimize construction waste and avoid structural over design by maximizing value engineering capabilities of the building.

vi. Provide for the use and/ or application of alternative energy sources that will allow the building to become more self-reliant. A simple solar hot water heater is a start. Utilization of photovoltaic/diesel hybrid systems for power generation or ground source heat pumps for building heating and cooling or other available sources would be optimal

vii. Building briefing on sustainability and green construction processes. Initiate a briefing on how the design, materials, and construction of the building will achieve your initial stated goals on sustainability and green construction. This briefing is a summary of the above areas and designates a time frame to the sections. This briefing should be prior to the start of the construction process and contractor selection. Insist that the following systems be addressed at a minimum:

    1. Passive solar design of the building (site layout)
    2. Xeriscape principles (site landscape and impact applications)

3. Type of energy efficient model to be utilized
4. Construction Team selection criteria
5. Construction Materials and component selection (IAQ, SBS, Energy Efficiency)
6. Construction energy systems: HVAC, Lighting, etc...
7. Alternative energy sources utilized – why, why not?
8. Insist on an initial briefing on the operations and maintenance procedures of the building to verify that the system components are not going to be over burdensome.

Construction

At this phase of the project, a vast majority of the questions relating to green construction processes have already been completed. However, there are a few areas that a commander should be concerned with.

viii. Initiate a plan for construction waste recycling and reuse/salvage applications.

ix. Insist that the inspection process devote an applicable amount of time to reviewing sustainable and green construction process that were initiated at in the Pre-Design Section. This quality follow-up process is integral toward ensuring compliance with national governmental compliance codes and standards.

Post Occupancy of the Building

The post-occupancy phase is an integral function of the green construction process. However, extensive interviews on the applicability of an operations approach

toward sustainable design can produce differing opinions. This researcher tends to agree with the trend that operation and maintenance should be a separate function of the green construction process. If, however, the initial building components are chosen wisely, then the building or facility energy manger will have a reduced load of complexity.

x. Post occupancy evaluation should center on process that will be utilized during the next building construction phase. A "best-practices" listing can be developed and briefed to the commander to ensure that selective processes were achieved in relation to green construction practices.

For a checklist summary, please refer to Table 1.0, page 27.

Further Investigation

This research paper was designed to provide an introductory approach toward the green construction principles that would allow for further investigation on building efficiency processes for military facilities. There are many questions that are yet to be answered, but could be brainstormed into focus areas for further investigation and research. The following is a culmination of side conversations during the interview process of this papers focus. They are not intended to enlist more than additional thought, based on the above foundation of the applicability in providing the most energy efficient buildings at all military bases, posts, or facilities.

Further Study # 1.0: Further expansion of the regional facilities engineering support concept that NAVFAC utilizes in their design and construction process (Appendix, Page 32) to incorporate national climate zone standards for building

Table 1.0

construction. Extensive development in reducing the fifteen planting climate zones (Appendix, Page 33) under four quadrants based on minimum and maximum temperatures and humidity and rainfall applications. An updated map could then be established that would provide locations of all DoD facilities with respect to what standard design considerations might be universally adaptable.

Further Study # 2.0: Initiate standards of location data that would provide alternative energy source requirements for all DoD facilities. Utilize standard wind, solar, and geothermal data for standard applications of their use and compliance (Appendix, Pages 34-36)

Further Study # 3.0: Initiate selective materials applications with respect toward facilities construction. For example: hook and loop carpeting, no-VOC paints and adhesives, straw board and wheat board instead of plywood, fly-ash added to concrete mixtures, and other alternative building materials that may provide a cornerstone for advertising the structure as one-of-kind within the DoD facility community.

CONCLUSION

In summary, this research study has presented a foundation of an energy efficient approach toward green construction for military facilities. This introductory study developed a cross flow of information from the DoD branches and produced current applications in the paradigms of sustainable design and construction.

Characteristics of this paper include a shift in the principles of the construction community. Civil engineering members must include the constructors as a professional

team member, fully capable of understanding and applying the techniques of sustainability and green construction practices. Allowing these members to become a part of an overall construction team will produce a quality energy efficient building.

The above research also illustrated the complexity of utilizing one term to describe an energy efficient process in construction. Using sustainability or green construction or another expression of environmental design procedures will not diminish the fact that the structure must be, by definition, energy efficient. Noticeable missing from this research is a baseline to what is considered energy efficient. Working from the complexity of the current codes, executive orders, programs, and military policies, this researcher did not want to further muddle the existing aspects of what is considered energy efficient. Rather, this paper focused on utilizing existing programs and codes instead of developing a new and complex program of sustainability project evaluation

Another aspect of this research paper was to set forth a small number of case study applications to provide some sense of what has worked in the past few years. Notably, these case studies deal with alternative energy sources as a fundamental application toward non-dependency on the typical energy grid. This one area should be further investigated and utilized at every DoD installation to some degree. Throughout the DoD there exists ample applications, large and small, to provide an integrated approach toward alternative energy sources.

The pinnacle of this research paper focused on the possibility of producing a simple DoD publication and or checklist for front-line base commanders and his or her staff. This checklist could provide simplistic questions to pose at initial planning stages of the construction process to further set the foundation of a green construction project. It is

completely applicable to note that most commanders hold a extreme amount of power when it comes to new "milcon" spending on their base, post or facility. Utilizing that power, and a certain amount of pressure to the base civil engineering community, one commander can be educated on basic principles of green construction practices and certainly make a difference in the outcome of their building.

Green construction provides for environmental energy efficiency though planning and design and incorporating these aspects into the entire construction process. Green construction for military facilities isn't that difficult. It is a process by which fundamental energy efficient practices are set and achieved throughout the building process. It is readily achievable and can produce significant energy saving to the DoD, while ensuring that the building remains habitable – sustainable for years to come.

APPENDIX

NOTES

[1] Haltenhoff, C. Edwin, The CM Contracting System: Fundamentals and Practices (New Jersey, Prentice-Hall, Inc., 1999)

[2] Senge, Peter, The Fifth Discipline (New York, Doubleday and Company, Inc., 1994)

[3] The New Lexicon Webster's Encyclopedic Dictionary of the English Language (1995)

[4] Chapman, Richard N., Photovoltaics in the Department of Defense (DOE Contract AC04-94AL85000)

[5] Ibid.

[6] HQ, USAF Center for Environmental Excellence, USAF Environmentally Responsible Facilities Guide, Page 78. Brooks AFB

[7] EPA Fact Sheet – Sick Building Syndrome <www.epa.gov.iag/pubs/sbs.html>

[8] Ibid.

[9] HQ, USAF Center for Environmental Excellence, USAF Environmentally Responsible Facilities Guide, Page 2. Brooks AFB

[10] Antoniades, Anthony C., Architecture and Allied Design: An Environmental Design Perspective (Iowa, Kendall / Hunt Publishing Company 1986)

[11] Pro-Act Fact Sheet: Sustainable Development, August 1998 – TI#18185 <www.afcee.brooks.af.mil/pro_act/fact/Aug98a.htm>

[12] A Definition of "Sustainable Building" <www.egret.net/tufts/definition.htm>

[13] Defense Environmental Network and Information Exchange, Energy Efficiency at the Department of Defense <www.denix.osd.mil/denix/Public/News/OSD/Climate/energy.html>

[14] HQ, USAF Center for Environmental Excellence, Draft Memorandum for ALMAJCOM/CE – Civil Engineering Sustainability Policy, 07/13/00

[15] 11 August 1994, Secretary of Defense. Environmental Building News – Navy Policy on Sustainability <www.ebuild.com/archives/Other_copy/NavyPolicy3.html>

[16] ASHRAE Standard 90.1

[17] Turchen, Stephen and Conner, Craig, Making Sense of the Model Energy Code <http://hem.dis anl.gov/eehem/96/960308.html>

[18] Spencer, Ambrose Concerns About LEED Program, Environmental Building News, Vol 8, Number 2 February 1999 <www.buildinggreen.com>

[19] BEPAC

[20] Spencer, Ambrose Concerns About LEED Program, Environmental Building News, Vol 8, Number 2 February 1999 <www.buildinggreen.com>

[21] Green Building Products – New Software now Available – Building for Environmental and Economic Sustainability (BEES) <www.ofee.gov/html/software.htm>

[22] Leadership in Energy and Environmental Design (LEED) <www.usgbc.org>

[23] Federal Energy Management Program (FEMP) EPACT 1992 <www.eren.doe.gov/femp>

[24] Environmental Building News – Navy Policy on Sustainability <www.ebuild.com/archives/Other_copy/NavyPolicy3 html>

[25] Federal Energy Management Program (FEMP) <www.eren.doe.gov/femp/greenfed/1.0/1_2_current_federal_reg htm>

[26] Ibid.

[27] Ibid

[28] Ibid.

[29] Ibid.

[30] Ibid.

[31] Environmental Building News – Navy Policy on Sustainability <www.ebuild.com/archives/Other_copy/NavyPolicy3.html>

[32] White House Publications <www.pub whitehouse gov/search>

[33] Ibid.

[34] Environmental Building News – EO 13123 <www.buildinggreen.com/news/executive.html>

[35] Federal Energy Management Program (FEMP) <www.eren.doe.gov/femp>

[36] Environmental Protection Agency, Sustainable Building Technical Manual: Green Building Design, Construction, and Operations, (Public Technology 1996) National Institute of Building Sciences, Construction Criteria Base # 50 4th Quarter 1999.

[37] Green Seal <www.greanseal.org>

[38] Energy Efficency and Renewable Energy Network (EREN) <www.eren.doe.gov/solarbuildings>

[39] Center of Excellence for Sustainable Development <www.sustainable.doe/index.shtml>

[40] Morgan Tim, Energy Star shines down on Planet: Program Saves consumers money, protects environment The Fresno BEE, Friday, December 24, 1999.

[41] Energy Star <www.epa.gov/energystar>

[42] DODI 4170.10 Energy management Policy <http://web7.whs.osd.mil/text/i417010p.txt>

[43] Defense Energy Support Center (DESC) <www.desc.dla.mil>

[44] Flanders, Stephen N. (lead) DRAFT – Working Prototype for DoD Sustainable Installations Rating Tool (SIRT) Prototype, June 2000

[45] Sustainable Project Rating Tool (SPRT) US Army Corps of Engineers Construction Engineering Reseaecch Laboratory <www.cecer.army.mil/td/tips/index.cfm>

[46] USAF Publications, Air Force Instruction (AFI) 32-1023

[47] HQ, USAF Center for Environmental Excellence, USAF Environmentally Responsible Facilities Guide, Brooks AFB

[48] HQ, USAF Center for Environmental Excellence, Draft Memorandum for ALMAJCOM/CE – Civil Engineering Sustainability Policy, 07/13/00

[49] Construction Engineering Research Laboratory <www.cecer.army.mil>

[50] Army Environmental Policy Institute, Enviroene, (AEPI) <http://es.epa.gov/program/p2dept/defense/army/dodaepi html>

[51] Naval Facilities Engineering Command (NAVFAC) National Institute of Building Sciences, Construction Criteria Base # 50 4th Quarter 1999.

[52] Ibid.

[53] Ibid.

[54] Memorandum of Understanding between the US Army Coprs of Engineers, The Naval Facilities Engineering Command, and the Air Force Civil Engineer on Unified Design Guidance, Tri-Services Working Group National Institute of Building Sciences, Construction Criteria Base # 50 4th Quarter 1999.

[55] Chapman, Richard N., Photovoltaics in the Department of Defense (DOE Contract AC04-94AL85000)

[56] Ibid.

[57] Ibid.

[58] Ibid.

[59] Enxco Product Data Sheet. Enxco, Denmark.

[60] Ibid.

[61] COSO Geothermal Development Brochure, Geothermal Program Office, Naval Air Weapons Station, China Lake, California.

[62] HQ, USAF Center for Environmental Excellence, USAF Environmentally Responsible Facilities Guide, Page 41, Brooks AFB

[63] HQ, USAF Center for Environmental Excellence, USAF Environmentally Responsible Facilities Guide, Page 20, Brooks AFB. Additional Information utilized from the Xeriscape Demonstration Garden Brochure at the Zilker Botanical Garden Center, Austin, Texas.

[64] US Postal Service <www.usps.gov/environ/webpages/havasu.htm>

[65] Interview Process, Ft. Irwin Army Post Team Meeting, 9 March 2000

[66] Specifications, composite Support Facility / C.E. Readiness Facility Fresno Air national Guard Base, Fresno California. Booker Gery Hickman Architects, Inc.

[67] HQ, USAF Center for Environmental Excellence, USAF Environmentally Responsible Facilities Guide, Page 24, Brooks AFB